

Prevalence of and risk factors for serum antibodies against *Leptospira* serovars in US veterinarians

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Objective—To determine the seroprevalence of antibodies against *Leptospira* serovars among veterinarians and identify risk factors for seropositivity in veterinary care settings.

Design—Seroepidemiologic survey.

Study Population—Veterinarians attending the 2006 AVMA Annual Convention.

Procedures—Blood samples were collected from 511 veterinarians, and serum was harvested for a microcapsule agglutination test (MAT) to detect antibodies against 6 serovars of *Leptospira*. Aggregate data analysis was performed to determine the ratio of the odds of a given exposure (eg, types of animals treated or biosafety practices) in seropositive individuals to the odds in seronegative individuals.

Results—Evidence of previous leptospiral infection was detected in 2.5% of veterinarians. Most veterinarians reported multiple potential exposures to *Leptospira* spp and other pathogens in the previous 12 months, including unintentional needlestick injuries (379/511 [74.2%]), animal bites (345/511 [67.5%]), and animal scratches (451/511 [88.3%]). Treatment of a dog with an influenza-like illness within the past year was associated with seropositivity for antibodies against *Leptospira* spp.

Conclusions and Clinical Relevance—Veterinarians are at risk for leptospirosis and should take measures to decrease potential exposure to infectious agents in general. Diagnostic tests for leptospirosis should be considered when veterinarians have febrile illnesses of unknown origin. (*J Am Vet Med Assoc* 2009;234:938–944)

Because of their frequent contact with multiple animal species, veterinarians are at risk of contracting zoonotic infections.¹ In 2005, the CDC and the AVMA conducted a survey² of veterinarians that included their perceived risk of acquiring zoonotic diseases. Leptospirosis was reportedly a concern for 33.7% of small animal veterinarians and 59.0% of large animal veterinarians.

Leptospirosis is a bacterial disease affecting humans and other animals. Fewer than 100 human cases of leptospirosis were reported in the United States from 1984 through 1994, the last year in which leptospirosis was a nationally notifiable disease.³ Symptoms may include headache, fever, myalgia, conjunctivitis, nausea, vomiting, and diarrhea or constipation.⁴ Infection with *Leptospira* spp ranges from subclinical to mild, influenza-like illness to serious multisystemic and hepatic disease (Weil's disease). Meningitis, meningoencephalitis, or pulmonary hemorrhage with respiratory failure may also result.⁵ Leptospiral infection during pregnancy may cause abortion.⁶ Mild infec-

ABBREVIATIONS	
CI	Confidence interval
GHLIT	Group Health & Life Insurance Trust
IgM	Immunoglobulin M
MAT	Microcapsule agglutination test
NVSL	National Veterinary Services Laboratories
OR	Odds ratio

tions may also lead to future chronic disease, including chronic fatigue, neuropsychiatric symptoms, and eye infections.^{5,7} Leptospirosis is often not diagnosed because symptoms may be nonspecific and laboratory diagnosis is difficult.⁵ The mortality rate for infected humans ranges from < 5% to 30% in various parts of the world.⁵

Leptospire, excreted in animal urine or tissues of parturition, can survive for weeks to months after becoming established in soil or water. Animals and humans become infected after contact with this soil or water, which may happen by ingestion of contaminated

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food or water or through contact with abraded skin and mucosal surfaces, such as an eye or nose. Veterinarians and others may also become infected as a result of contact with infected tissues, body fluids, and organs from infected animals through direct contact or aerosol transmission. Veterinarians and others exposed to infected animals (ie, dogs, rodents, cattle, swine, goats, sheep, and horses), animal products, or contaminated soil or water as part of their work can acquire leptospirosis occupationally.⁷⁻¹⁰

Of particular concern to veterinarians is the increasing incidence of diagnosis of leptospirosis in dogs and other animals.^{11,12} In the lower peninsula of Michigan, > 20% of healthy dogs were found to have antibodies against *Leptospira* serovars, most of which were historically uncommon serovars.¹³ Researchers have also reported a higher incidence of leptospirosis in dogs that have access to potentially contaminated bodies of water.¹²

Despite the known risk of infection to veterinarians in the United States, the incidence and prevalence of leptospirosis in this population remains largely undefined. Few seroepidemiologic studies have been conducted, and we are unaware of any national seroepidemiologic surveys of veterinary workers in the United States. The purpose of the study reported here was to estimate the prevalence of antibodies against *Leptospira* spp and identify factors that influence the risk of infection.

Materials and Methods

Study subjects—The study population was healthy, practicing veterinarians, 18 years of age or older, attending the 143rd AVMA Annual Convention from July 15 through July 19, 2006, in Honolulu.

During the convention, health and wellness screening for attendees was performed at the AVMA GHLIT wellness booth. The booth was open to all veterinarians, their spouses, and veterinary students attending the convention. Health screenings available to attendees included full hematologic and serum biochemical analyses, determination of serum concentration of prostate-specific antigen for males > 40 years of age, and determination of blood hemoglobin concentration for females. Measurement of serum antibody titer against rabies virus was also available to booth attendees when they had not been evaluated for that titer within the last 3 years. The study protocol was reviewed and approved by the Institutional Review Board at Emory University.

Specimen and data collection—Informed consent and authorization under the Health Insurance Portability and Accountability Act was acquired from each participant. Afterward, a 10-mL blood sample was collected from each participant into a serum separator tube by experienced laboratory personnel. The serum separator tube was centrifuged at $1,800 \times g$ for 8 minutes. Serum was removed and stored at 4°C (39°F) or frozen until it was shipped by expedited delivery to Emory University, where samples were stored at -70°C (-94°F).

Veterinarians were asked to complete a self-administered survey. The standardized survey was designed to obtain information on participant demographics,

reported recent exposure to zoonotic diseases, animal specialty, clinic experience, accidental vaccination, recent illness and injury, and frequency of use of personal protective equipment and other infection control practices (eg, handwashing, not recapping needles prior to disposal, or not eating, drinking, or smoking in animal-handling areas). The survey and serum sample of each participant were coded with the same unique identifier to maintain confidentiality.

Serum antibody testing—An aliquot of each serum sample was sent from Emory University to the Athens Veterinary Diagnostic Laboratory at the University of Georgia, where antibody testing was performed. An MAT was used to detect antibodies against *Leptospira* serovars Bratislava, Canicola, Grippotyphosa, Hardjo, Icterohemorrhagiae, and Pomona, as described elsewhere.^{14,15} All testing and reading of results were performed by the same technician who had been trained and had successfully completed the 2006 USDA NVSL proficiency testing for the leptospirosis MAT. A cutoff titer of 1:100 was adapted to the testing conditions of the Athens Veterinary Diagnostic Laboratory by standardizing the endpoint readings with serum samples of known endpoints supplied by the NVSL in the 2006 leptospirosis proficiency serum panel. The MAT included 1 positive control sample of known titer and 1 negative control sample (titer < 1:100). A participant was considered seropositive for antibody against *Leptospira* spp when the antibody titer against any of the aforementioned serovars was $\geq 1:100$; all others were considered seronegative.^{5,16-18}

Subanalyses were performed on the basis of information from other reports and results from initial analysis. Because other researchers have used a seropositive cutoff titer of 1:200, we also considered individuals with a serum titer of 1:200 as seropositive and considered all other veterinarians (including those with an antibody titer of 1:100) as seronegative.¹⁷ Initial laboratory findings indicated that the predominant reactive serovar was Bratislava; therefore, individuals with a 1:100 titer against any serovar other than Bratislava were excluded from the subanalysis. Individuals with a titer against Bratislava of $\geq 1:100$ were considered seropositive and compared with the remaining seronegative individuals.

Participants were not informed of their results for anti-*Leptospira* antibodies because the laboratory used for testing is not certified through the Clinical Laboratory Improvement Amendments program. Furthermore, there was no anticipated clinical benefit to providing serologic results because antibodies are indicative of previous rather than acute or recent infection.

Statistical analysis—Data were entered into a database^a and analyzed in aggregate form with commercially available statistical software.^b Medians of ordinal variables were calculated, and these variables were dichotomized at their medians for use in additional analyses. Comparisons between seropositive and seronegative veterinarians were evaluated with a Fisher exact test for ordinal and dichotomous variables, and a value of $P < 0.05$ was considered significant.

Exact logistic regression was used to determine ORs and 95% CIs, comparing the odds of a given exposure among veterinarians seropositive for anti-*Leptospira*

antibodies with the odds among veterinarians seronegative for anti-*Leptospira* antibodies.¹⁹ An OR met significance when the associated *P* value was < 0.05 , indicating that the 95% CI for the OR did not include the null value of 1.0.^{20,21} Variables that achieved a significance of $P < 0.10$ in the univariate analyses, variables that have been associated with leptospirosis in other studies, and biologically plausible variables were considered for inclusion in a multivariate logistic regression model of risk factors for seropositivity. A backward selection method was used to create the final multivariate logistic regression model; because of the small sample size, exact estimates were used for the ORs and 95% CIs.

Results

General characteristics of study veterinarians—During the AVMA Annual convention in 2006, 1,112 individuals (49.4% female) attended the AVMA GHLIT wellness booth. The status of these individuals (eg, veterinarian, spouse of veterinarian, or veterinary student) was unknown. Of these, 535 (48.1%) were enrolled in the study. Twenty-four (4.5%) were excluded because their serum sample was missing, they did not have a DVM degree, or they spent $\leq 50\%$ of their working time in clinical veterinary practice. Therefore, 511 veterinarians were ultimately included. The median age of veterinarians was 46 years (range, 25 to 81 years; interquartile range, 35 to 54 years). Two hundred fifty-seven (50.4%) veterinarians were female, and 253 (49.6%) were male.

Veterinarians practiced in various geographic regions of the United States as follows: southeastern, 36.6%; western, 24.5%; midwestern, 22.9%; and northeastern, 13.9%. The remaining 2.1% of veterinarians indicated they worked outside the United States. One hundred seventy-five of 494 (35.4%) veterinarians indicated they had traveled internationally. Most veterinarians (353 [69.2%]) reported that they worked in small (companion) animal practice, followed by mixed small and large animal (105 [20.6%]), exotic animal (26 [5.1%]), equine (9 [1.8%]), food animal (including livestock and poultry; 5 [1.0%]), or another practice type (12 [2.4%]). Nearly all veterinarians reported treating dogs (479 [93.7%]) and cats (479 [93.7%]). Less than a third had treated small ruminants (164 [32.1%]), horses (163 [31.9%]), cattle (148 [29.0%]), exotic mammals (138 [27.0%]), mammalian wildlife (121 [23.7%]), swine (107 [20.9%]), exotic livestock (100 [19.6%]), or poultry (98 [19.2%]).

Thirty-three of 487 (6.8%) veterinarians believed they had contracted a zoonotic disease through their work, with most of these individuals (20 [60.6%]) reporting they were exposed through skin or mucosal surfaces. Other suspected routes of transmission were fecal-oral (7 [21.2%]), inhalation (7 [21.2%]), parenteral inoculation (1 [3.0%]), and other (5 [15.2%]). Thirty-five of 486 (7.5%) veterinarians reported having inadvertently inoculated themselves with the vaccine against *Leptospira*. Of the 268 of 464 (57.8%) veterinarians who reported treating an animal with leptospirosis, 86.2% reported treating a dog, 19.8% treated a cow, 5.2% treated a pig, 0.4% treated a rodent, and 3.7% treated another type of animal. The median number of animals with leptospirosis treated per year was 3 (interquartile range, 2 to 6).

In response to questions regarding general measures taken to prevent infection, most veterinarians reported sometimes or always wearing disposable gloves (86.7%), a laboratory coat or equivalent (71.0%), and a surgical mask (66.3%). Most veterinarians (94.7%) reported sometimes or always washing hands before eating, drinking, or smoking, and 96.9% reported washing hands after evaluating an animal. Fewer than half of the veterinarians (42.5%) reported sometimes or always wearing eye protection. Approximately half of the veterinarians (55.0%) reported sometimes or always eating, drinking, or smoking in animal handling areas.

Over the previous year (July 2005 to July 2006), 345 (67.5%) veterinarians were bitten by an animal such that the skin was broken at least once and 220 (43.1%) were bitten at least twice. During the same period, 451 (88.3%) veterinarians were scratched by an animal such that the skin was broken at least once and 411 (80.4%) reported at least 2 animal scratches. Most veterinarians reported at least 1 unintentional needlestick injury (379 [74.2%]) and almost half (248 [48.5%]) reported ≥ 2 in the previous year. Most veterinarians (431 [84.3%]) reported that they sometimes or always recapped needles before disposal. One hundred eighty-eight (36.8%) veterinarians reported being cut by a surgical or necropsy instrument at least once and 97 (19.0%) reported being cut ≥ 2 times within the previous year.

Serum antibody testing—Thirteen of the 511 (2.5%) participating veterinarians had a titer of $\geq 1:100$ for antibody against *Leptospira*, and 7 veterinarians had a titer that exceeded 1:100. The most common leptospiral serovar against which serum antibodies were detected was Bratislava, which was detected in 10 veterinarians. Five of these had a titer of 1:100, 1 had a titer of 1:200, 1 had a titer of 1:400, and 3 others had a titer of 1:800. Two of the veterinarians that were seropositive for serovar Bratislava with a titer of 1:800 were also seropositive for serovar Icterohemorrhagiae (titer, 1:400). Of the remaining 3 veterinarians, one had antibody against serovar Icterohemorrhagiae (titer, 1:800), the second had antibody against serovar Hardjo (titer, 1:800), and the third had antibodies against serovars Pomona (titer, 1:200), Icterohemorrhagiae (titer, 1:800), and Grippityphosa (titer, 1:100). None of the seropositive individuals had antibody against serovar Canicola.

Of the 13 seropositive veterinarians, 6 were female. All 13 reported treating dogs or cats in the past year, and 6 reported treating an animal with a diagnosis of leptospirosis. None of the 13 reported having a previous diagnosis of leptospirosis, and none reported having inadvertently inoculated themselves with vaccine against *Leptospira* (Table 1). Although 1 of 494 (0.2%) veterinarians reported having a previous diagnosis of leptospirosis, this individual was not seropositive at the time of testing.

Factors associated with a serum anti-*Leptospira* antibody titer of $\geq 1:100$ —Results of univariate analyses indicated that, among the 511 participating veterinarians, neither gender nor primary type of practice was associated with an anti-*Leptospira* antibody titer $\geq 1:100$ (Table 1). With the exception of a report of

Table 1—Results of univariate exact logistic regression analyses of factors potentially associated with seropositivity for anti-*Leptospira* antibodies in US veterinarians.

Variable*	No. (%) seropositive	No. (%) seronegative	OR	95% CI	P value†
Age ≥ 46 y vs ≤ 45 y (511)	7 (53.8)	242 (48.6)	1.23	0.35–4.51	0.93
Female vs male (510)	6 (46.2)	251 (50.5)	0.84	0.23–2.97	0.98
Type of practice (510)					
Small animal	7 (53.8)	346 (69.5)	1.00	—	Ref
Mixed	5 (38.5)	100 (20.1)	2.47	0.60–9.25	0.23
Equine	1 (7.7)	8 (1.6)	6.11	0.12–58.27	0.37
Exotic animal	0 (0)	5 (1.0)	7.66	0–63.96	1.00
Food animal	0 (0)	26 (5.2)	1.41	0–9.75	1.00
Other	0 (0)	12 (2.4)	3.08	0–22.43	1.00
Type of animal treated (511)					
Dogs	13 (100)	466 (93.6)	1.24	0.20–∞	0.85
Cats	13 (100)	466 (93.6)	1.24	0.20–∞	0.85
Ferrets	7 (53.8)	278 (55.8)	0.92	0.26–3.38	1.00
Rabbits	6 (46.2)	323 (64.9)	0.47	0.13–1.64	0.27
Horses	6 (46.2)	157 (31.5)	1.86	0.51–6.58	0.41
Cattle	5 (38.5)	143 (28.7)	1.55	0.39–5.48	0.63
Wildlife	4 (30.8)	117 (23.5)	1.45	0.32–5.30	0.74
Small ruminants	4 (30.8)	160 (32.1)	0.94	0.21–3.43	1.00
Reptiles	4 (30.8)	149 (29.9)	1.04	0.23–3.80	1.00
Pocket pets	4 (30.8)	315 (63.3)	0.26	0.06–0.94	0.04
Exotic mammals	4 (30.8)	134 (26.9)	1.21	0.27–4.41	0.97
Exotic livestock	3 (23.1)	97 (19.5)	1.24	0.22–4.94	0.97
Avian (nonpoultry) species	3 (23.1)	166 (33.3)	0.60	0.11–2.37	0.65
Swine	2 (15.4)	105 (21.1)	0.68	0.07–3.19	0.93
Poultry	2 (15.4)	96 (19.3)	0.76	0.08–3.58	1.00
Symptoms in previous month (511)					
Flu-like symptoms	3 (23.1)	36 (7.2)	3.83	0.65–15.80	0.14
Headache	11 (84.6)	261 (52.4)	4.98	1.07–46.71	0.04
Muscle aches	6 (46.2)	132 (26.5)	2.37	0.65–8.41	0.21
Fever	2 (15.4)	23 (4.6)	3.74	0.38–18.70	0.26
Lethargy	5 (38.5)	87 (17.5)	2.94	0.74–10.49	0.13
Vague	3 (23.1)	74 (14.9)	1.72	0.30–6.88	0.62
Vomiting	2 (15.4)	17 (3.4)	5.11	0.51–26.36	0.16
Diarrhea	2 (15.4)	123 (24.7)	0.55	0.06–2.59	0.69
Conjunctivitis	1 (7.7)	22 (4.4)	1.80	0.04–13.24	0.91
Liver	0 (0)	2 (0)	16.00	0–210.7	1.00
Other symptoms	0 (0)	11 (2.2)	2.50	0–16.82	1.00
Fever > 37.8°C (100°F) in past year (511)	5 (38.5)	171 (34.3)	1.19	0.30–4.22	0.97
Treated dog with influenza-like illness in past year (511)	12 (92.3)	328 (65.9)	6.20	0.90–267.41	0.07
Believe contracted zoonotic disease within the past year (487)	0 (0)	33 (6.9)	0.81	0–5.07	0.85
Routine contact with water (river, stream, ocean, lake, pond, ditch, sewage, or other; 492)	7 (53.8)	330 (68.9)	0.53	0.15–1.93	0.39
Ever inadvertently inoculated with vaccine against <i>Leptospira</i> (486)	0 (0)	35 (7.7)	0.79	0–5.03	0.84
Ever treated animal with leptospirosis (464)	6 (50.0)	262 (58.0)	0.73	0.19–2.76	0.79
Type of animal treated for leptospirosis (268)					
Dog	4 (66.7)	227 (86.6)	0.31	0.04–3.55	0.30
Cow	2 (33.3)	51 (19.5)	2.06	0.18–14.84	0.68
Swine	0 (0)	14 (5.34)	2.22	0–16.53	1.00
Rodent	0 (0)	1 (0)	43.70	0–1,703	1.00
Other type of animal	0 (0)	10 (3.8)	3.19	0–24.40	1.00
Traveled internationally within past year (494)	5 (38.5)	170 (35.3)	1.14	0.29–4.04	1.00

*Within this column, values in parentheses represent total number of veterinarians. †A value of $P < 0.05$ was considered significant in univariate analyses.
 — = Not applicable. Ref = Referent group.
 Seropositivity was defined as an antibody titer of $\geq 1:100$ against any leptospiral serovar.

a headache, those with anti-*Leptospira* antibodies were no more likely to have been symptomatic in the previous month than other veterinarians. International travel within the past year was not an independent risk factor for seropositivity. A greater proportion of seropositive veterinarians reported treating a dog with an influenza-like illness in the past year, compared with the proportion of seronegative veterinarians, although the difference was not significant. Treatment of pocket pets was the only factor significantly associated with seropositivity.

Being bitten or scratched by an animal, having received an unintentional needlestick injury, or being cut by a surgical or necropsy instrument did not increase the odds of leptospiral seropositivity (data not shown). There were no associations between reported biosafety practices and use of personal protective equipment and seropositivity (data not shown).

On the basis of results of the univariate analyses, a full multivariate model was created, including the variables treatment of pocket pets and treatment of a dog with influenza-like illness in the past year. Because report of a headache within the month prior to the survey lacked clinical specificity for previous *Leptospira* infection, it was not included. Results of the multivariate model indicated that treatment of pocket pets (OR, 0.21; 95% CI, 0.05 to 0.76; $P = 0.01$) and treatment of a dog with influenza-like illness in the past year (OR, 8.21; 95% CI, 1.17 to 358.00; $P = 0.03$) were significant predictors of a positive antibody response to *Leptospira*.

Factors associated with a serum anti-*Leptospira* antibody titer of $\geq 1:200$ —Eight (1.6%) veterinarians had a high antibody titer ($\geq 1:200$). All 8 (100%) reported that they had treated a dog with influenza-like illness in the past year, compared with 332 of 503 (66.0%) seronegative veterinarians (including the 5 veterinarians with antibody titers of 1:100; $P = 0.08$). Seven (87.5%) veterinarians with a high antibody titer were > 46 years of age, compared with 242 (48.1%) seronegative veterinarians ($P = 0.06$). Three (37.5%) veterinarians with a high antibody titer reported influenza-like symptoms in the past month, compared with 36 (7.2%) seronegative veterinarians (exact OR, 7.72; 95% CI, 1.15 to 41.5; $P = 0.04$). One (12.5%) veterinarian with a high antibody titer reported treating pocket pets, whereas 318 (63.2%) seronegative veterinarians (exact OR, 0.083; 95% CI, 0.002 to 0.658; $P = 0.01$) reported the same thing.

Factors associated with a serum antibody titer of 1:100 against Bratislava—Ten (2.0%) veterinarians had a serum antibody titer of 1:100 against *Leptospira* serovar Bratislava. Of various influenza-like symptoms, only headache was significantly associated with seropositivity for Bratislava (exact OR, 8.15; 95% CI, 1.11 to 359.68; $P = 0.03$).

Discussion

In the present study of veterinarians attending the 143rd AVMA Annual Convention in 2006, 13 of 511 (2.5%) veterinarians had evidence of previous leptospiral infection. Other estimates of the seroprevalence of leptospirosis include 1.8% among all practicing

veterinarians in Illinois between 1956 and 1972,²² 1% among veterinarians in New Zealand in 1974,²³ and 2.9% among Austrian veterinarians in 1994.²⁴ We might have expected fewer leptospiral infections given advances in and greater use of vaccines against *Leptospira* in veterinary medicine. At the same time, there are reports^{11,12} of increases in leptospiral infections in wild animals in the United States and a concomitant increase in infections in domestic animals, particularly dogs.

The first veterinary vaccine, developed for dogs in the 1950s, protected against *Leptospira* serovars Icterohemorrhagiae and Canicola. The first trivalent vaccine containing distemper virus, infectious canine hepatitis virus, and *Leptospira* serovar Canicola for dogs was licensed in 1961.²⁵ In 2000, a new leptospirosis vaccine was introduced, which included not only *Leptospira* serovars Icterohemorrhagiae and Canicola but also Pomona and Grippotyphosa, to address emerging changes in the distributions of infections by the various serovars.²⁶ In the study reported here, 10 of 13 seropositive veterinarians had antibody against *Leptospira* serovar Bratislava, which is not included in the canine vaccine. This serovar predominantly infects pigs and horses but has been associated with illness in dogs as well.^{4,16}

Four of the 13 seropositive veterinarians in the present study had antibody against *Leptospira* serovar Icterohemorrhagiae, which has been included in the canine vaccine since original production.²⁷ Rodents are the primary reservoir of this serovar, and they may serve as a source of infection for humans as well as other animals.¹⁶

Only 1 veterinarian had antibodies against *Leptospira* serovars Pomona and Grippotyphosa, and none were seropositive for antibodies against Canicola. Because dogs are the primary reservoir for *Leptospira* serovar Canicola,¹⁶ and this serovar has been included in the old and new vaccines used in dogs, our results were not surprising. Vaccinated animals may still become subclinically infected and shed leptospires in their urine.^{4,28,29} The American Animal Hospital Association Canine Vaccine Task Force has recommended that vaccination of dogs against *Leptospira* be limited to use in areas where there is a reasonable risk of exposure, primarily because of lack of information on prevalence of various serovars in different geographic areas as well as the risk of postvaccination reactions.³⁰ In cows, sheep, and pigs, annual vaccinations against *Leptospira* are recommended for confined animals, whereas semiannual vaccination should be considered for open herds.³¹

There are several rapid serologic assays for the diagnosis of leptospirosis. These include the slide agglutination assay,³² indirect hemagglutination assay,³³ MAT,³⁴ immunofluorescence assay,³⁵ ELISA for IgM,^{36,37} IgM dipstick assay,³⁸ and IgM dot-ELISA dipstick test.³⁹ Limitations of these assays include low sensitivity in subjects tested during the first week of illness (whole-cell based serologic assays), the requirement for specialized laboratory equipment such as a fluorescence microscope (immunofluorescence assay), the need for skilled personnel to perform the assay (ELISA), and the inability to detect the infecting serogroup. The gold standard is the MAT, with a sensitivity of 98.2% (95% CI, 95.8% to 100.6%) and specificity of 96.4% (95% CI,

95.0% to 97.9%).¹⁴ The MAT allows for the differentiation of infecting serogroups. However, few laboratories perform MATs because of the expense and technical expertise required.¹⁴ Typically, positive results from acute serum samples (from blood samples collected ≤ 14 days after the onset of symptoms of leptospirosis) and convalescent serum samples (from blood samples collected ≥ 15 days after onset of symptoms) are used to make a definitive diagnosis. A positive result from a single serum sample ($\geq 1:100$ MAT titer) may indicate previous infection because antibodies against *Leptospira* spp may persist for many years.^{7,39-43}

Because we used an MAT on 1 serum sample from each participating veterinarian, we are unable to determine the time frame during which they were exposed to *Leptospira*. It is possible that the proportion of veterinarians who were exposed to *Leptospira* during their lifetime was greater than the proportion that we detected. Additionally, we only tested for antibodies against 6 leptospiral serovars. If we had tested for antibodies against a broader spectrum of serovars, we may have detected a higher seroprevalence than we did. Cross-reaction between serovars may also have occurred.

As of December 31, 2006, there were 81,468 veterinarians practicing in the United States, 47.1% of whom were female.⁴⁴ This percentage is similar to our study sample, in which 50% of veterinarians were female. The proportion of veterinarians in our study who worked with small animals (69%) was similar to that of the general veterinarian population in the United States (66%)⁴⁴; however, the proportion of veterinarians who worked at mixed animal practices was not (21% in our study vs 7.8% in the whole United States). Given these findings, caution should be used when attempting to generalize our results to the US population of veterinarians.

Treatment of pocket pets and dogs with influenza in the previous year were the only factors significantly associated with leptospiral seropositivity when multivariate analysis was performed in the present study. The protective association with pocket pets was either spurious or related to other characteristics of small animal veterinarians that were not measured. For example, veterinarians who treated pocket pets may have been more likely to work in urban areas and may consequently have been less likely to have come in contact with animals infected with *Leptospira*.

Veterinarians who treated dogs with influenza-like illness in the previous year were more likely to have an antibody response to the *Leptospira* serovars evaluated. Some signs of leptospirosis and influenza-like illness in dogs are similar. Dogs with leptospirosis may have non-specific signs including fever, depression, lethargy, anorexia, arthralgia or myalgia, and oculonasal discharge. As the disease progresses, clinical signs may include vomiting, dehydration, lumbar pain from renomegaly and nephritis, tongue-tip ulceration and necrosis, intussusception, pulmonary hemorrhage, uveitis, pneumonitis, chronic hepatitis, and reproductive failure.³¹ Influenza-like illness in dogs may also be evident as fever, nasal discharge, and persistent cough.^{45,46} The similarity between the signs of leptospirosis and those of influenza-like illness suggests that veterinarians treating ill dogs may be putting themselves at risk for exposure to zoonotic pathogens such as *Leptospira*.

The potential for the veterinarians in our study to have been exposed to zoonotic pathogens is remarkable. Indeed, 74.2% of 511 participating veterinarians reported an unintentional needlestick injury at least once in the past year. In 1998 and 1999, the frequency of needlestick injuries was reportedly 0.45/person/y among companion animal veterinarians and 2.03/person/y among large animal veterinarians.^{47,48} Most veterinarians (84.3%) in our study reported that they sometimes or always recapped needles before disposal, a known risk factor for pathogen transmission in veterinary settings.⁴⁹ Another study revealed similar findings in that 63% of veterinarians mostly or always recapped needles prior to disposal.² This practice has been regulated in human medicine through the implementation of the Bloodborne Pathogens Regulation (1910.1030) since 1992⁵⁰; the practice has been discouraged in veterinary animal medicine since 2006.⁵¹ Thus, veterinarians should be encouraged to always dispose of uncapped needles in an approved sharps container.

In another study,² $< 5\%$ of veterinarians reported wearing appropriate respiratory or eye protection when handling products of conception and only 6.3% of small animal veterinarians reported wearing appropriate personal protective equipment when examining an animal with respiratory signs. In the present study, frequency of use of personal protective equipment was poor, yet most veterinarians reported treating an animal with a diagnosis of leptospirosis. Although no association was evident between lack of protective equipment use and evidence of leptospiral infection, this may have been attributable to the fact that most veterinarians did not use such protection; thus, the power to detect an association was limited. It is essential that personal protective equipment such as gloves, barrier gowns, and eye protection be worn when handling animals with leptospirosis or products (eg, urine or tissue) from animals suspected of having leptospirosis.⁵² In the event of a high-risk exposure (eg, direct contact with urine or blood from an infected animal via mucosal membranes or broken skin), the World Health Organization recommends postexposure prophylaxis with doxycycline.^{53,54}

Although it is impossible to eliminate the occupational risk of exposure to zoonotic pathogens in veterinary practice, the risk of infection can be mitigated through early recognition and appropriate management of infected or potentially infected animals, use of good personal hygiene and personal protective equipment, avoidance of recapping needles, as well as proper animal handling and housing. The *Compendium of veterinary standard precautions: zoonotic disease prevention in veterinary personnel*⁵¹ provides valuable information and guidelines for the prevention of the transmission of zoonotic pathogens from animals to veterinary personnel.

- a. Microsoft Access 2003, Microsoft Corp, Redmond, Wash.
- b. SAS, version 9.1, SAS Institute Inc, Cary, NC.

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